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Spatial heterogeneity and sensitivity analysis of crop virtual water content at a global scale

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In this study, the green and blue virtual water content (VWC) of four staple crops (i.e. wheat, rice, maize, and soybean) is quantified at a high resolution scale, for the period 1996-2005, and a sensitivity analysis is performed for model parameters.
In each grid cell, the crop VWC is obtained by the ratio between the total crop evapotranspiration over the growing season and the crop actual yield. The evapotranspiration is determined with a daily soil water balance that takes into account crop and soil properties, production conditions, and climate. The actual yield is estimated using country-based values provided by the FAOSTAT database multiplied by a coefficient adjusting for the spatial variability within countries. The model improves on previous works by using the newest available data and including multi-cropping practices in the evaluation.
The overall water use (blue+green) for the global production of the four grains investigated is 2673 km3/yr. Food production almost entirely depends on green water (>90%), but, when applied, irrigation makes production more water efficient, thus requiring lower VWC. The spatial variability of the virtual water content is partly driven by the yield pattern with an average correlation coefficient of 0.83, and partly by reference evapotranspiration with correlation coefficient of 0.27. Wheat shows the highest spatial variability since it is grown under a wide range of climatic conditions, soil properties, and agricultural practices.
The sensitivity analysis is performed to understand how uncertainties in input data propagate and impact the virtual water content accounting. In each cell fixed changes are introduced to one input parameters at a time, and a sensitivity index, SI, is determined as the ratio between the variation of VWC referred to its baseline value and the variation of the input parameter with respect to its reference value.
VWC is found to be most sensitive to planting date (PD), followed by the length of the growing period (LGP) and the crop actual yield (Ya), while it is less sensitive to the reference evapotranspiration (ET0) and available soil water content (AWC).